

Study on Useful Cases Sharing among Multi-site Factories by Support System of Kaizen Activity

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Abstract

This paper discusses a support system of Kaizen activity for effective sharing useful cases among multi-site factories. After the framework of the support system which consists of three basic elements, that is, Kaizen case-base, model-base and user-interface, is described quoted by Decision Support System (DSS), a design of a procedure of new case development which is put in the user-interface particularly is the focus. Furthermore, Kaizen technology applied to the new case development is Visual Management (VM) technology as one of the useful technologies. The proposed procedure consists of the following five phases: 1) identification of current burden, 2) selection of useful case, 3) new case design for improving direct burden, 4) improved designed case for enhancement of technological level and 5) improved designed case for contribution to overall system. In addition, a case study is performed to assure the relevance of the proposed procedure by put the emphasis on VM of chemical plant. Then the proposed procedure is qualified based on systematic evaluation and experts' opinion as useful method to Kaizen knowledge transfer through collaboration with a factory eager to implement VM.

Keywords

Multi-site Production Strategy; Knowledge Management; Technology Transfer; Kaizen Activity; Visual Management (VM); Decision Support System (DSS)

Introduction

This paper focuses on how to share useful cases and how to utilize shared cases in Kaizen activity under the globalization of factory location. The reason is that there is a diversification of capability level to improve projects and its output level among several factories. Moreover, these factories tackle the same burdens. However, they don't know each other's activity. As the result of this, a difference of an evaluation result of Key Performance Indicators (KPIs) among them occurs.

Further, most of improvement projects depend on expert's experience or intuition, resulting in more time required to resolve new project neglected. Additionally, most factories put emphasis on the accumulation of experience through participation in many projects. Therefore, it is inadequate for them to design and utilize an education system to teach excellent Kaizen cases and related methodologies. Of course, several factories have developed retrieval system of successful cases with software obtained from general market. However, an effective utilization of the system depends on user's skill.

In order to install and establish Kaizen activity, young engineers who will support their production system in the future, have to learn Kaizen know-how, to improve their capability and to solve a lot of projects and such a cycle have been continued. It is as well necessary to transfer expert's knowledge and technology from experts to inexperienced engineers. Systematization of the both cycles is one key point to maintain competitive superiority of each factory under the global competitiveness. On the other hand, an enhancement of Visual Management (VM) technology as one of the representative Kaizen technology is expected to effectively utilize large-scale and complicated production system (Murata and Katayama 2010). The reason is that VM tech. contributes to the improvement of related KPIs and is an interface between manufacturers and production system.

Based on the facts as mentioned above, the purpose of this paper is development of a support system for Kaizen activity in the production department. In order to achieve the purpose, three outcomes are submitted.

- A support system of Kaizen activity by

Decision Support System (DSS)

- A procedure of new VM case development as one main function of proposed support system
- A case study of new case development to confirm the utility of proposed procedure at the collaborated company which has multi-site factories

This paper consists of the six sections. In the next section, Kaizen activity management is investigated to draw an overall picture on support objects of Kaizen activity. Proposed support system of Kaizen activity is described in the third section. A procedure for new case development is designed in the fourth section. A case study is performed in the fifth section, followed by the proposed procedure in the previous section, and conclusions are made in the final section.

Management of Kaizen Activity

Two axes to find attributes of management activities are proposed by Gorry and Morton (1971). One axis means three management activities. They consist of strategic planning, management control and operational control. First activity is a prediction of business environment and a construction of business strategy based on the predicated results. While second activity is a suitable supplementation and an effective utilization of various resources such as talented people, the newest equipment and environment-friendly materials and so on. Third activity is an implementation of specified operations in order to work production function.

The other axis means three categories of support system of management activity. They consist of structured support system, semi-structured support system and unstructured support system. An example of first system is Electronic Data Processing (EDP). An example of third system is DSS. While an example of second system is put between EDP and DSS.

A framework of management information system of Kaizen activity illustrated in Table 1, has been referred by Gorry and Morton's axes. In particular, the first axis is specialized for Kaizen activity. A strategic planning of Kaizen activity is a process to consider a scheme to construct a future production system in top management level. A management control of Kaizen activity is a process to analyze the results of implemented projects and to set next projects in

manager level. An operational control of Kaizen activity is a process to implement projects and to measure the results of projects by manufacturer level. As stated above, these roles are given to all members from top side to operational side. And the mechanism is traditionally one of the important features of Kaizen activity and contributes to the solution to a missing link in corporate strategy (Skinner 1969).

As the other axis, a structured system supports a management of target/result values of KPIs in management level. Managed indicators are such as 1) the rate of machine operation, 2) operation efficiency, 3) the rate of material consumption, 4) the amount of products in stock and 5) the amount of products in progress. In addition, the system supports a management of how to measure target/result values and when to measure them in manufacturer level. A common keyword of two support activities is "an evaluation support of Kaizen activity".

Semi-structured system supports a management of Kaizen technology assets in management level. The functions are an accumulation, a classification and a reuse of developed Kaizen technologies. Moreover, the system supports a management of every project progress in manufacturer level. In this support, a recovery plan is made when loss time occurs in each project. A common keyword of two support activities is "an implementation support of Kaizen activity".

Unstructured system supports a planning of strategy in top management level. Top management have to determine a basic Kaizen scheme such as Total Productive Management/ Maintenance (TPM) (Shirose 1996), Total Quality Management (TQM) and Lean Management (Womack and Jones 2003) etc. As well, the system supports a management of Kaizen engineers' skill in management level. Concrete support activities are an extraction of Kaizen skills, an education planning of each engineer and a confirmation of their education progress. Moreover, the system supports a development and an application of teaching material in manufacturer level. A common keyword of three support activities is "an education support of Kaizen activity".

Support System of Kaizen Activity

A lot of systems have been developed by DSS (Chan, et al. 2000, Halsall and Price 1999, Suri and Whitney 1984). Sprague and Watson's framework (1979), in the

TABLE 1 A FRAMEWORK OF MANAGEMENT INFORMATION SYSTEM OF KAIZEN ACTIVITY

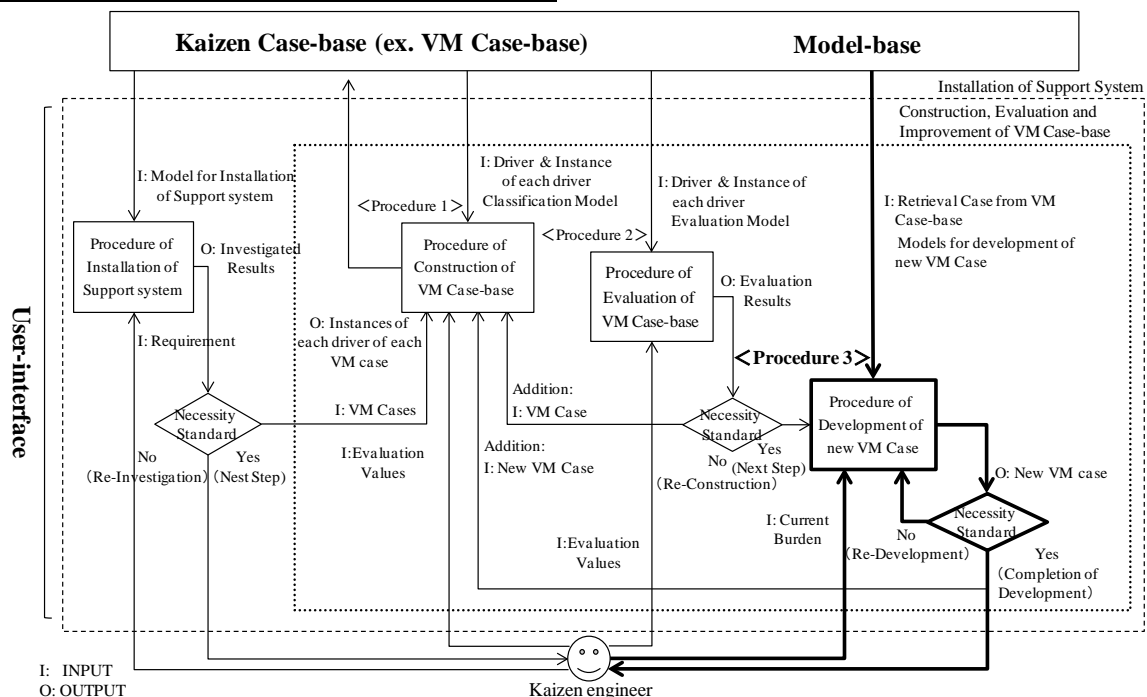
Purpose A kind of support system	Operational control	Management control	Strategic planning
Structured	Management of how to measure target value of KPIs and result value of KPIs -How to measure both values of KPIs -When to measure both values of KPIs etc.	Management of plan value of KPIs and actual value of KPIs -The rate of machine operation -Operation efficiency -The rate of material consumption -The amount of products in stock -The amount of products in progress etc.	-
Semi-structured	Management of project progress	Management of Kaizen technology assets	-
Unstructured	Support of implementation of Kaizen project	Management of skill of Kaizen engineers	Kaizen strategic planning

focus of this study, consists of three elements such as data-base, model-base and decision-maker. Furthermore, in order to control information flow among two bases and decision-maker, data-base management system, model-base management system and user-interface are located in the system. Decision-maker accesses data-base and model-base to get useful data and models and to make various decisions on business management through utilizing them followed by user-interface.

Proposed system in this paper consists of three elements such as Kaizen case-base as one data-base of Kaizen activity, model-base and user-interface quoted by the framework mentioned above. FIG. 1 shows a relationship among three elements. And then explanations of each element are described in the each following sub-section. In addition, after the explanation, proposed procedure of new VM case development is focused (See procedure 3 in FIG. 1). The reason is that it is directly connected to develop VM case as one final output for objective burden. Detailed explanation of the procedure is described in next section. And then the utility of the procedure is confirmed through a case study by means of proposed procedure in section after next.

Kaizen Case-base

It is important to perform PDCA (Plan-Do-Check-Action) Cycle (Lillrank and Kano 1989) effectively for



*Bold-arrow (Procedure 3): The scope of this paper

FIG. 1 PROPOSED SUPPORT SYSTEM OF KAIZEN ACTIVITY

a success of performance improvement project for high productivity organization, skilled manager and fine product and service. Two data-bases are proposed (Murata and Katayama 2009).

Firstly, KPI/KAI (Key Activity Indicator) database, the center of proposed evaluation system of factory performance, is useful to support plan step, check step and action step (Murata and Katayama 2009). KAI data accumulated to KPI/KAI database on the way to practice improvement project, are registered to KPI/KAI database after the completion of improvement project. Based on the supplied two categories' values, a factory performance value is calculated in check step. Three categories' data, i.e. KPI data, KAI data and factory performance value, are useful to analyze a gap between target value and obtained actual data as one evaluation of improvement project results. In action step and plan step, three categories' data are useful to investigate results of previous improvement projects and setting target value of next improvement project. These operations in three steps are considered as benchmarking process.

Secondly, Kaizen case-base put in do step (Murata and Katayama 2010). Compact and useful Kaizen technologies, e.g. VM technology, POKA-YOKE technology (Erlandson et al. 1998), KARAKURI technology (Ohno 1998), are accumulated to Kaizen case-base which supplies suitable Kaizen technologies for improvement project. In order to understand specifications of the case-base, a classification of it is discussed from three viewpoints such as 1) utilization purpose of it, 2) its information structure and 3) its accumulated data type.

In the first viewpoint, Kaizen case-base has three utilization purposes such as 1) detection and solution of hidden abnormalities in production system, 2) prevention of the occurrence of abnormalities in production system and 3) loss reduction of production system. In the first purpose, hidden abnormalities are detected in the production system. If they occur, Kaizen engineers deal with them urgently based on obtained information from the category's technologies. The case-base examples are diagnosis technology case-base and VM case-base. In the second purpose, a recurrence of past abnormalities is prevented in the production system. The case-base examples are POKA-YOKE case-base and maintenance prevention (MP) case-base. In the third purpose, detected losses

which are a root cause of abnormalities are eliminated. The case-base examples are 5S technology case-base and weight reduction technology Case-base and so on. In this paper, VM case-base is all focused.

In the second viewpoint, an information structure of Kaizen case-base is a relational database which is illustrated from upper two tables of FIG. 2. Left side case-base is utilized by implementation department of Kaizen activity and right side case-base is utilized by support department of Kaizen activity. Extracted attributes of accumulated cases in the former case-base will be different from that in the latter case-base. However, two bases have common information structure as shown in lower table of FIG. 2. Two defined terms are utilized for classification of a Kaizen case. One is driver which means category of attributes of Kaizen case. The other is instance which means member of driver characterized Kaizen case. For instance, Kaizen cases lined up in a column and drivers lined up in a row, a matrix can be made with a number of instances which multiply a number of Kaizen cases by a number of drivers.

In the third viewpoint, there are three kinds of accumulated data in Kaizen case-base such as 1) image data, 2) sentence data and 3) numerical value data. Examples of the three levels of data are photo of a total of a case and detail sketch of Kaizen technology utilized in a case; profile data of case by keyword and/or sentences; established plan value and measured actual value such as development cost and development period and so forth, respectively.

Owing to the use of two tools, i.e. KPI/KAI database and Kaizen case-base, supporting a total of PDCA Cycle effectively can be realized.

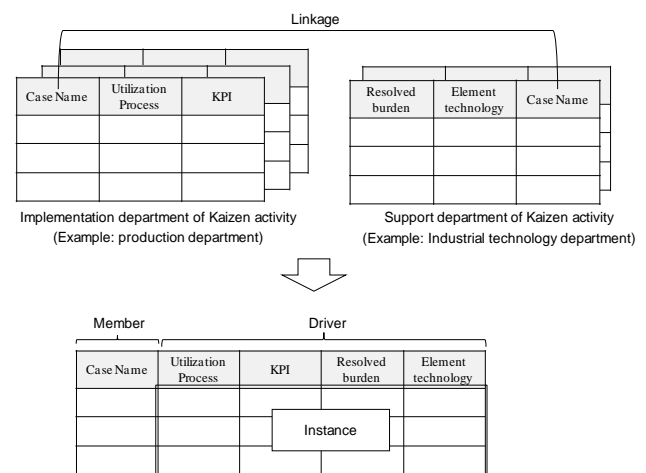


FIG. 2 INFORMATION STRUCTURE OF KAIZEN CASE-BASE

Model-base

Model-base accumulates useful models for an effective utilization of Kaizen case-base, including three kinds of model such as Kaizen strategic model, Kaizen objective model and Kaizen data analysis model, which is quoted by model-base structure of Sprague and Watson's DSS (1979).

First model provides an organizational structure and an implementation procedure to synthetically and systematically promote Kaizen activity. Through utilization of this model, a competitiveness of an enterprise is reinforced. Model examples are TPM model, TQM model, lean management model, Management Resource Planning II (MRPII) model and Balanced Scorecard(BSC) model (Kaplan and Norton 1992).

Second model provides a prototype of various functions in a production system. In case of the improvement of a function in production system, an essential problem-solving can be expected through analysis of a gap between a current state and a target state given by means of the related model. There are eight kinds of models in order of model scale as follows.

- demand forecast model
- order management model
- ordering and indicating model
- production system model
- production planning model
- layout model
- delivery system model
- operation model

Third model is utilized to analyze data accumulated in Kaizen case-base, to make decision based on the data and to make graphs based on the result of the data analysis and decision making. There are three kinds of models according to technological features.

- multivariate analysis model
- decision making model
- model for making graph

Furthermore, it will be necessary to develop advanced models which integrate these fundamental models to effectively utilize accumulated data in Kaizen case-base.

User-interface

Utilization of the proposed system is based on four procedures of user-interface such as installation procedure of support system, construction procedure of VM case-base, evaluation procedure of VM case-base and development procedure of new VM case. Outline of three procedures for utilization function of the system except installation procedure is described as follows. In addition, the object of the three procedures is VM technologies which are one of the useful Kaizen technologies in production sector. In the construction procedure of VM case-base, Kaizen engineers extract instance of each driver in each case to clarify attributes of all cases based on driver/instance information delivered from the support system. In evaluation procedure of VM case-base, Kaizen engineers make a relationship data between cases and KPIs based on accumulated data in the case-base, and analyze the data based on offered models from model-base and evaluate a degree of a contribution of cases to KPIs. If the evaluation result is undesirable, it is necessary to add cases, by means of which the result is improved. In the development procedure of new case, Kaizen engineers analyze a current burden depending on useful methodologies such as operation analysis and/or why-why analysis offered based on model-base, as well as retrieve suitable cases from VM case-base according to the results of the analysis and develop new case to resolve the current burden with retrieved cases.

Procedure of New VM Case Development

In order to deploy strategically Kaizen technologies among factories, three directions of case development are considered as follows; 1) reproduction of case similar to developed case, 2) improvement of technological level of developed case and 3) diversification of application range of developed case.

The first direction is to develop a new case similar to a benchmark case. Similar points are considered such as an elemental technique of a case, a technological level of a case and an application purpose of a case and so on. In the direction, a benchmark case is retrieved from VM case-base and utilized to develop a new case to resolve current burden. Owing to the development process, a quantitative expansion of VM case-base will be realized.

The second direction is to develop a new case with higher function than a benchmark case. The development in the direction is supported according to the six technological levels such as first level:

visualization of unusual phenomena, second level: visualization of root cause, third level: visualization of spill-over effect, forth level: visualization of procedure to cope with the problems, fifth level: visualization of real time action sequence for problem solving and six level: visualization of 100% normality. In the direction, a technological level of cases in VM case-base is improved with technological levels. Owing to the development process, cases accumulated in VM case-base will have wide technological levels.

The third direction is to develop a new case which is applied to other burdens except resolved burden by a benchmark case. In the direction, a benchmark case is retrieved from VM case-base and the element techniques of the retired case is utilized to resolve other burdens except burden resolved by it. Owing to the development process, an expansion of application range of cases in VM case-base will be realized.

Based on three development directions, the proposed procedure consists of the following five phases: 1) identification of current burden, 2) selection of useful case, 3) new case design for improving direct burden, 4) improved designed case for improvement of technological levels and 5) improved designed case for contribution to overall system.

The relationship among three development directions and five phases of proposed procedure is as follows. For the first direction, first phase to third phase is utilized. For the second direction, fourth phase is utilized. For the third direction, fifth phase is utilized. Detail explanation of each phase is described as the following chapters.

Identification of Current Burden (phase 1)

The purpose of this phase is to prepare a retrieval of useful cases from VM case-base in the next phase. The preparation consists of the following three sub-phases: 1) a description of the overall circumstances of current burden, 2) a consideration of spill-over effect from the current burden and 3) a selection of words of the current burden. Particularly, in the third phase, words are extracted through analyzing cases of selected spill-over effect based on why-why analysis (Shirose 1996). The methodology is one of the methodologies of cause analysis supplied from the model-base.

Selection of Useful Case (phase 2)

The purpose of this phase is to select useful case to resolve the direct burden. Firstly, relevant cases are retrieved from VM case-base based on words

established in the previous phase. Secondly, one useful case to resolve a current burden is selected from retrieved cases. When a comparison among retrieved cases is performed, instances of each driver in each retrieved case are utilized. If an accumulated number of retrieved words which conform to instances of retrieved case are high value, the retrieved case will have a close relationship with the current burden. Therefore, the more the accumulated number is, the better the retrieved case is regarded as a useful case. Establishment of drivers of investigated VM cases is performed through referring to 4W3H questions and drivers (Murata and Katayama 2010). Eleven drivers of cases are: 1) KPIs to be improved, 2) advantage of application of VM, 3) burdens before application of VM, 4) resolved burden after application of VM, 5) business category, 6) related manufacturing process, 7) visualized item, 8) elemental techniques to realize VM, 9) VM technological level, 10) development cost of VM and 11) other VM cases related to a case. If useful case can be selected from retrieved cases, development of VM goes to next phase. If the useful case cannot be selected from retrieved cases, exchange of other retrieved words and re-retrieval of relevant cases from VM Case-base is performed.

New Case Design for Improving Direct Burden (phase 3)

The purpose of this phase is to design new case supported by the selected case from second phase. In the phase, a template of the VM technology of the selected case is utilized. The function of the template is to provide the relevant parameters to realize effective VM technology. How to use the template consists of two sub-phases. Firstly, related parameter is selected from parameter variations, which means a design of VM specification. Secondly, new case is embodied through the utilization of selected parameters.

Improvement of Designed Case for improving technological levels (phase 4)

The purpose of this phase is to upgrade designed case based on the six technological levels mentioned above. The procedure of this phase consists of two sub-phases. Firstly, one relevant level of designed case is identified based on six levels. Secondly, a design of other five levels' cases is considered.

Improvement of Designed Case for Contributing Overall System (phase 5)

The purpose of final phase is to improve designed case

which contributes to the improvement of the performance of overall system that is the final target of the concerned organization, where current burden is involved, based on the other cases related to the designed case. In order to retrieve the other related cases from VM case-base, defined score is given to each case in VM case-base according to the classification model of Kaizen case (Murata and Katayama 2011). The purpose of the model is an integration of both scores calculated by Quantification Theory Category III (Hayashi and Suzuki 1975, Hayashi 1993) and AHP (Saaty 1977, Saaty 1994) with the aim of a trial of an integration of explicit knowledge and tacit knowledge because Quantification Theory Category III analyzes quantitative data and AHP analyzes qualitative data.

Evaluation Standards of Developed Cases

The utility of developed cases by means of the design process from phase one to phase five has been checked with the four evaluation standards. If the four evaluation standards are not satisfied, re-design of new case is performed from initial phase such as first phase and second phase.

- Whether the elemental technologies of retrieved case is applied to case development or not.
- Whether it will be possible to resolve current burden by means of developed case or not (For confirmation of a capability of third phase).
- Whether the technological level of developed case is higher than that of retrieved case or not (For confirmation of a capability of fourth phase).
- Whether the application range of developed case is wider than that of retrieved case or not (For confirmation of a capability of fifth phase).

Case Study of New Case Development

Case study is performed through collaboration with multi-site factories of one chemical company eager to implement VM in Keihin Industrial Zone, Japan. In particular, two Kaizen experts are the person to contact the investigation of the case and the discussion of application results of the proposed procedure. The period of the project including the case study is about two years.

Identification of Current Burden of Sample Project (a trial of phase 1)

Sample Kaizen project in investigated chemical plant

is illustrated as follows. The theme of the project is "A management of the pipeline of warm water at a high place". Objective product at the ground floor in the plant is supplied to next process through the sending line set up in the pipe rack at 3.5 meters above the ground. It is possible to freeze the product because the temperature falls lower than the freezing point of the product during the winter months (from October and March). The countermeasure is to wind the pipeline of warm water on the sending line. The pipeline of warm water is closed to prevent useless flow of warm water during the summer months (from April and September). However, it is difficult to check the present conditions of the valve's opening and closing of the pipeline from the ground floor. The reason is that the valve of the pipeline is on the pipe rack. In addition, manufactures have to reach out their hand to operate the valve. The reason is that the distance between the valve and the scaffold, which is a scaffold for the tank near the pipe rack, is one meter. Furthermore, pipelines similar to target pipeline are on the pipe rack, resulting in the possibility to have negative influence on other process thanks to the operation of wrong pipeline.

Selection of keywords for the objective project mentioned above is performed for the preparation of retrieval to seek useful cases from VM case-base as following three sub-phases with why-why analysis.

Firstly, six spill-over effects are follows; 1) the freeze of the product because of the failure to open the pipeline of warm water, 2) the flowing of useless warm water because of the failure to close the pipeline of warm water, 3) falling from the ladder, 4) falling from the scaffold on the way to the operation, 5) wasting time to look for operated valves because of several similar pipelines on the pipe rack and 6) having negative influence on other process and operation because of the operation of wrong pipeline of warm water. The function of warm water is the countermeasure to supply the product without frozen product. Thus, a stable supply of the product is important from a viewpoint of evaluation on spill-over effects. From the point, first spill-over effect, "the freeze of the product", is considered the most important of the six.

Secondly, analysis of selected spill-over effect is performed by means of why-why analysis as shown in FIG. 3. The number of the analysis is four times. Results of the last analysis are five factors such as 1)

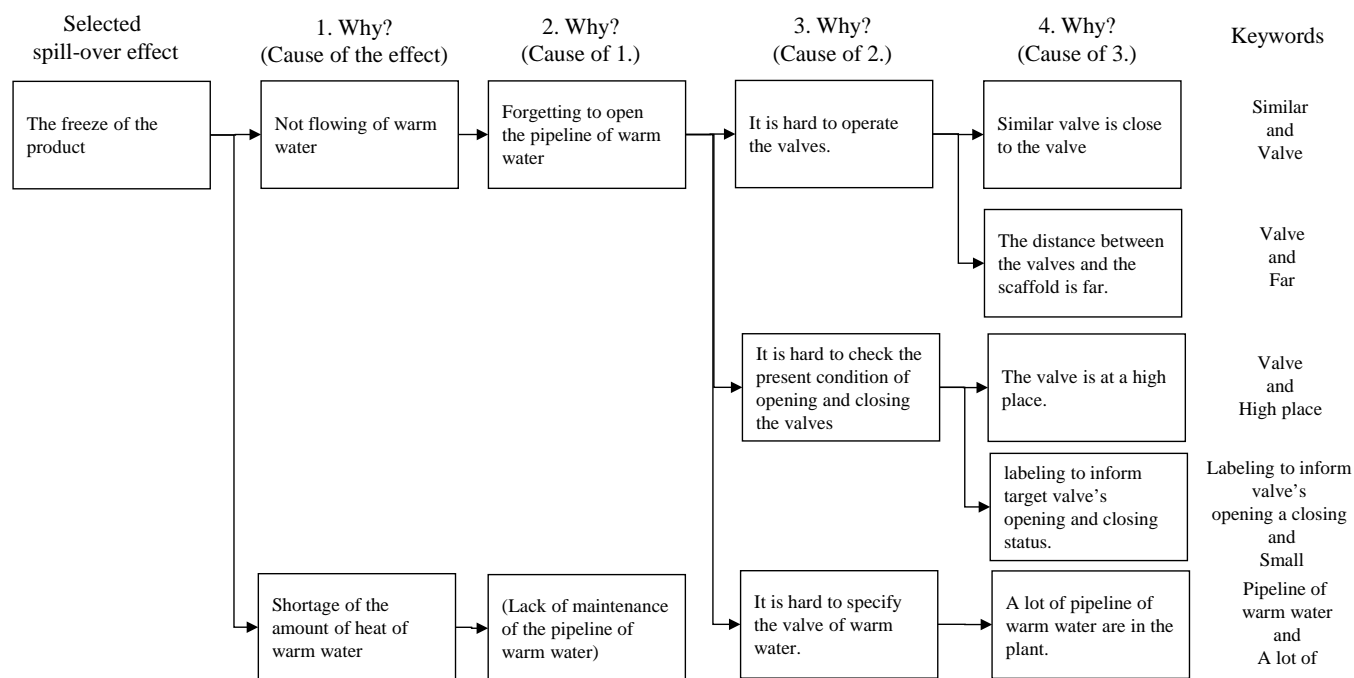


FIG. 3 RESULTS OF WHY-WHY ANALYSIS FOR SAMPLE PROJECT

similar valve is close to target valve, 2) the distance between target valves and utilized scaffold is long, 3) target valve is at a high place and 4) labelling to inform target valve's opening and closing status is in small size and 5) a lot of pipeline of warm water are in the plant.

Thirdly, the five pairs of keywords, such as a) similar & valve, b) valve & far, c) valve & high place, d) labelling to inform valve's opening a closing & small and e) the pipeline of warm water & a lot of, are selected from the results of the why-why analysis.

Selection of Useful Case to Current Burden (a trial of phase 2)

Retrieval to seek useful cases from constructed case-base is performed by the five pairs of keywords obtained from previous phases. The case-base is one electronic folder in Windows 7 Professional which is one of the general operating system consisting of one hundred and forty one electronic files examined by Microsoft PowerPoint 2007, in which one electronic file is one case. All cases are investigated in collaborated chemical company having two plants which stand at a distance. Therefore, it is possible that the two plants can utilize each other's useful case from the case-base. However, reciprocal cases aren't known for each other.

Retrieval engine equipped with Windows 7 Professional is utilized. This function of the retrieval

engine can retrieve full-text of the electronic file. For the retrieval results, a number of the retrieved cases are 2, 2, 1, 1 and 1 each pair of two keywords mentioned above. And six cases such as case 43, 46, 54, 106, 117 and 125 are selected, of which case 46 is retrieved at two times., while other five cases are retrieved at one time. When the deployment table of instances of each case is checked, the three points for new case development are found. They are 1) simplification of judgment on whether the valve is opened or not, 2) identification of operated valve and 3) improvement of valve operation circumstances. Consequently, selected case is case 43 through comparisons among six cases because the case has the all three points.

New Cases Design for Improving Direct Burden (a trial of phase 3)

In this phase, a design of new case is performed based on information obtained from two previous sections. Components of the selected case (case 43) are three main parameters such as 1) visualized process, 2) visualized object and 3) incidental information. Sub parameters of first parameter are 1-a) the beginning of visualized process, 1-b) the ending of visualized process and 1-c) a number of visualized processes. Sub parameters of second parameter are 2-a) a name of visualized operation instrument, 2-b) a number of visualized operation instruments, 2-c) a name of visualized state and 2-d) a number of visualized states.

By means of three parameters, the new cases are developed as shown in FIG. 3. For sub parameters of first parameter, 1-a) the beginning of visualized process is the tank of warm water, 1-b) the ending of visualized process is the pipeline of warm water and 1-c) a number of visualized processes is one. For sub parameters of second parameter, 2-a) a name of operation instrument is the valve for the operation of the pipeline of warm water, 2-b) a number of visualized operation instruments is one, 2-c) a name of visualized state is the valve's opening and closing state and 2-d) a number of visualized states is one. Further, a procedure of the operation of the pipeline of warm water is put on the new case as the third parameter, that is, incidental information.

Furthermore, ideas from three viewpoints are adopted in the new case as follows. 1) Adding the large label to inform whether the valve is opened or closed. 2) Adding the hand lever to the valves. 3) Lengthening the sending line of the product and the pipeline of warm water until the ground.

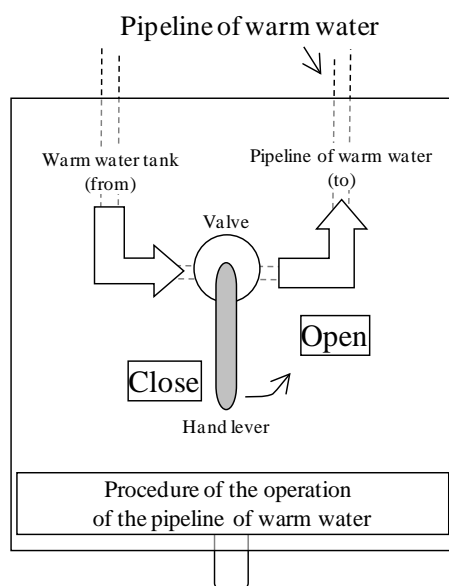


FIG. 4 DESIGNED CASE

Deployment of VM Technologies with Proposed Technological Steps (a trial of phase 4)

Technological level of the designed case is regarded as fourth level: visualization of procedure to cope with the problems, through discussion with experts. Because visualized items of the designed case are procedures to operate the pipeline of warm water. In addition, support parts for keeping the procedure is visualized by several elemental techniques such as the large label to inform whether the valve is opened or closed, the hand lever to the valves and visualization

of the direction of the flow of the pipeline and so on.

Cases of other five levels are designed as shown in Fig. 5. Visualized item and elemental technique of each case is described as follows. Visualized item of VM of first level is material flow, whose elemental technique is an implement for observe viscosity of material in sending line. Visualized items of VM of second level are temperature of material and warm water, whose elemental techniques are two thermometers for material and warm water with the indication of the freezing point of material. Visualized items of VM of third level are conveyance speed of material at a way in and out of pipeline, whose elemental techniques are flow meter to measure both speeds. The techniques are a part of the functions of computer integrated manufacturing (CIM). Monitoring indicators is performed at a control room. Visualized item of VM of fifth level is an indication of opening and closing of pipeline of warm water, whose elemental techniques are a sensor for detection of the time to switch over target valve. Visualized item of VM of final level is normal supply of warm water and conveyance of material, whose elemental technique is combination of elemental technique of third level and fifth level.

Improvement of Designed Case for Contributing to Overall System (a trial of phase 5)

The score of case 43 is closely related to the score of case 140 based on a calculation result (Murata and Katayama 2011).

Case 140 is visualization of the layout of all drain valves in the plant. Drainage of accumulated rainwater is necessary after raining, however, after that, it is possible to forget to close the valve. The reason is that a lot of drain valves are in the plant. Owing to it, harmful liquid utilized in the plant will flow outside the plant. Therefore, all valves are numbered and the valves described in the layout are numbered too. And a label to inform opening and closing state of each valve is put on each valve in the layout placed in the control room and the present condition of each valve is found on the layout.

Based on features of case 140, the deployment of case 43 to the overall plant will be considered to manage all values of all pipelines of the warm water in the plant. Actually, a number of similar valves are about four hundreds in the plant. Then, based on designed case as shown in FIG. 4, the integrated control system to operate valves of all pipelines of the warm water in the plant is designed as shown in FIG. 6.

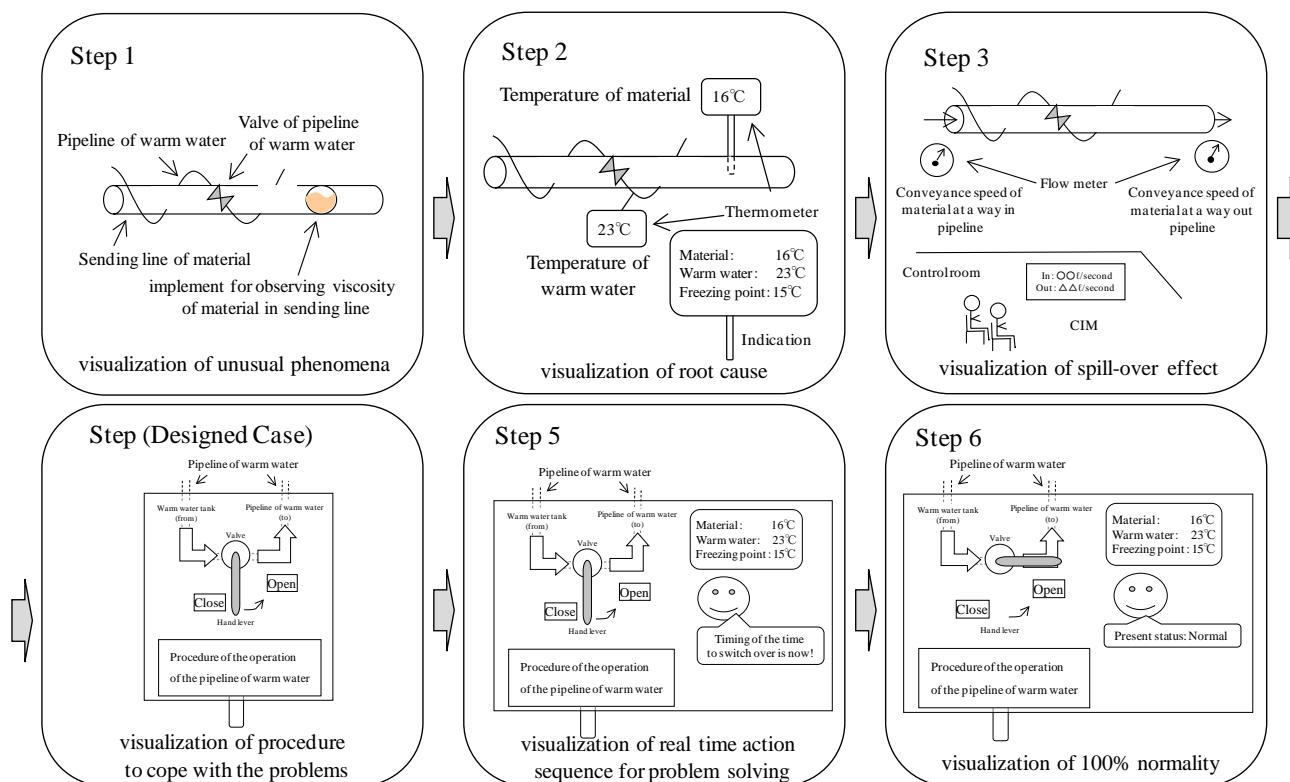


FIG. 5 SIX CASES FOR SAMPLE PROJECT BASED ON PROPOSED THECHNOLOGICAL LEVEL

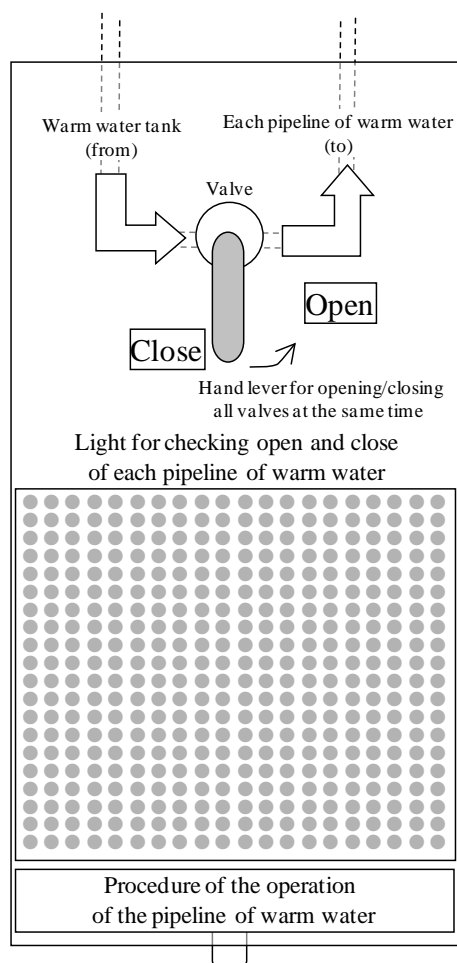


FIG. 6 IMPROVED DESIGNED CASE

Confirmation of the Utility of Proposed Procedure and Future Study

A confirmation of the utility of the proposed procedure is performed through the following two criteria. The first one is the four evaluation standards of developed cases. Firstly, designed case as shown in

FIG 4 is applied to elemental technologies of retrieved case (case 43).

Secondly, an installation of designed case as shown in FIG 4 is planned to resolve the current burden at the collaborated factory. Thirdly, two high level cases such as five level case and six level case as shown in FIG. 5 are realized. Fourthly, the application range of case as shown in FIG. 6 is wider than that of case 43.

The second one is an evaluation of Kaizen experts belonging to the collaborated factory who evaluate that inexperienced engineers can develop useful cases based on the proposed procedure. If the proposed procedure is utilized, it will be expected that inexperienced engineers will systematically develop new VM cases. Similarly, an improvement of their ability to extract essence of current burden will be expected. Based on the two discussions mentioned above, the utility of the proposed procedure is confirmed.

From the viewpoint of practical application, an

application of the proposed procedure can be expected to develop other Kaizen technologies. For example, KARAKURI technology and POKA-YOKE technology are applied to various performance improvement activities like VM technology.

Of course, this paper is just an initial step to realize systematically approach of Kaizen activity. The following tasks are mainly considered as three future works; 1) Development of a lot of successful case studies by means of the proposed procedure, 2) Systematization of effective registration procedure of developed cases in VM case-base and 3) Application of the proposed support system to educate inexperienced engineer. Moreover, in this paper, the procedure of new case development is the emphasis. It is important to evaluate the whole of the proposed support system from viewpoint of not only new case development but also construction and evaluation of VM case-base utilized by each related procedure in User-interface.

Conclusion Remarks

There are two proposals and one trial in this paper. For the first proposal, a framework of Kaizen activity support system was designed utilized by representative framework of DSS. The support system consists of three elements such as Kaizen case-base, model-base and an interface for effective utilization of the two assets. For the second proposal, a procedure of new VM case development was systematized. The procedure consists of five phases, that is, two retrieving phases including the preparation of the retrieving and three design phases based on proposed three directions of case development. For the trial, followed by the proposed procedure, a development of new cases was performed. Based on the submission of these outcomes, there is a step forward to realize effective Kaizen case sharing among multi-site factories.

In addition, there are two contributions of this paper in previous studies. Firstly, the proposed support system of Kaizen activity is one application case of Sprague and Watoson's DSS framework. Secondly, Nonaka (1994) insisted that it is necessary to organizationally transform tacit knowledge into explicit knowledge and transfer changed explicit knowledge within/among the organizations. However, the development of the transfer system is not enough. The trial of this paper developed by Kaizen experts is the initial contribution to systematize Kaizen activity such as a systematic education of Kaizen skills for

inexperienced engineers.

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